REMARKS

The application was filed with Claims 1-12. In the first Office action, Claims 1-12 were rejected. By this amendment, Claim 11 has been changed and Claim 13 has been added. Thus, Claims 1-13 are presented for further consideration.

Appointment of Associate Attorney

Pursuant to 37 C.F.R. §1.34(b), the principal attorney of record in this case has appointed the undersigned as an associate attorney herein. A document to this effect was executed by the principal attorney and sent to the Patent Office on 11/28/01, for filing in the above-identified application. For the convenience of the Examiner, a copy of the aforementioned appointing document is attached.

Brief Summary of the Invention

The present invention comprises a method to radiation harden a standard silicon-based semiconductor microcircuit. The microcircuit is heated in a vacuum furnace to remove any hydrogen deposited in the microcircuit's structure during the fabrication process. It is then annealed with forming gas containing deuterium to replace the hydrogen with deuterium. A microcircuit can also be radiation hardened by omitting the out-gassing step and using forming gas containing deuterium rather than hydrogen in the otherwise standard final passivating anneal. A further alternative is to substitute deuterium at each step in the microcircuit fabrication process whenever hydrogen gas or a hydrogen containing specie would otherwise be used. By removing hydrogen from the microcircuit, the foregoing processes of the present invention significantly increase the radiation hardness of the microcircuit while simultaneously reducing the hot carrier degradation and electrical stress induced leakage currents of individual circuit components.

The Office Action

The application was filed having Claims 1-12. The Office action rejected Claims 1-12 under 35 U.S.C. §102(e) as being anticipated by U. S. Patent No. 6,159,829 issued to Warren et al (hereinafter called "*Warren*").

Warren

Warren discloses a method for transforming an ordinary semiconductor into an electronic memory device. The memory mechanism involves the movement of hydrogenous ions, each containing a single proton, within a dielectric layer contained between two semiconducting layers having respective interfaces that impede the escape of the ions. A reversible electric field is applied across the dielectric layer to change the spatial position of the hydrogenous ions within the dielectric layer. The position of the hydrogenous ions remains the same unless intentionally moved by the application of a reversed electric field across the dielectric layer.

Since the positively charged protons create a positive electric field, their spatial position within the dielectric layer changes the conductivity of either of the abutting surfaces of the respective semiconducting layers enclosing the dielectric layer by attracting electrons from the semiconducting layer to the interface. The hydrogenous ions can be moved by applying a positive gate bias to create a conducting channel in the abutting semiconductor surface so that current will easily pass between the source and drain electrodes. This is "normally on" and is read as a bit state "1" when a high zero bias drain current is measured.

Conversely, a negative gate bias will repel the hydrogenous ions from the vicinity of the abutting semiconductor surface and consequently decrease the conductivity between the source and drain electrodes. This is "normally off" and is read as a bit state "0" when a low zero bias drain current is measured.

The introduction of mobile hydrogenous ions into the dielectric layer is enhanced by sudden cooling from the anneal temperature during the formation of a memory device.

Requirements for Prima Facie Anticipation

The Commissioner of Patents and Trademarks, acting through examining officials, bears the initial duty of supplying the factual basis supporting a rejection of a patent application, including a rejection based on anticipation. *In re* Warner, 379 F.2d 1011, 154 USPQ 173, 178 (C.C.P.A. 1967), *cert. denied*, 389 U.S. 1057 (1968). The courts have interpreted this initial duty as placing on the Commissioner and the examiner the burden of presenting a prima facie case of anticipation. *See In re* King, 801 F.2d 1324, 1327, 231 USPQ 136, 138-39 (Fed. Cir. 1986); *In re* Wilder, 429 F.2d 447, 450, 166 USPQ 545, 548 (C.C.P.A. 1970). As stated by the Board in *In re* Skinner, 2 USPQ 2d 1788, 1788-9 (B.P.A.I. 1986), "[i]t is by now well settled that the burden of establishing a prima facie case of anticipation resides with the Patent and Trademark Office."

A general definition of prima facie unpatentability is provided at 37 C.F.R. §1.56(b)(2)(ii):

> A prima facie case of unpatentability is established when the information *compels a conclusion* that a claim is unpatentable under the preponderance of evidence, burden-of-proof standard, giving each term in the claim its broadest reasonable construction consistent with the specification, and before any consideration is given to evidence which may be submitted in an attempt to establish a contrary conclusion of patentability.

(Emphasis added.)

"Anticipation requires the disclosure in a single prior art reference of each element of the claim under consideration." W.L. Gore & Associates v. Garlock, Inc., 721 F.2d 1540, 220 USPQ 303, 313 (Fed. Cir. 1983) (citing Soundscriber Corp. v. United States, 360 F.2d 954, 960, 148 USPQ 298, 301 (Ct. Cl.), *adopted*, 149 USPQ 640 (Ct. Cl. 1966)), *cert. denied*, 469 U.S. 851 (1984). Thus, to anticipate the applicants' claims, *Warren* must disclose each step recited therein. "There must be no difference between the claimed invention and the reference disclosure, as viewed by a person of ordinary skill in the field of the invention." Scripps Clinic & Research Foundation v. Genentech Inc., 927 F.2d 1565, 18 USPQ 2d 1001, 1010 (Fed. Cir. 1991).

To overcome the anticipation rejection, the applicants need only demonstrate that not all elements of a prima facie case of anticipation have been met, *i. e.*, show that *Warren* fails to disclose every step in each of the applicants' claims. "If the examination at the initial state does not produce a prima face case of unpatentability, then without more the applicant is entitled to grant of the patent." *In re* Oetiker, 977 F.2d 1443, 24 USPQ 2d 1443, 1444 (Fed. Cir. 1992).

Argument

An object of the applicants' invention is to remove existing hydrogen from within a standard microcircuit and replace it with deuterium. This replacement prevents the microcircuit's predictability and reliability from being adversely affected when the microcircuit is exposed to radiation, *i. e.*, it radiation hardens the microcircuit.

Warren discloses processes intended to ensure the availability of mobile hydrogenous ions in a semiconductor further to transforming an ordinary semiconductor into an electronic memory device. However, the presence of positively charged ions, *e. g.*, hydrogenous ions, in a standard semiconductor microcircuit is undesirable because, among several deleterious effects, the ions may move freely throughout the circuit and unpredictably change its performance and operating characteristics. Radiation exaggerates the unpredictability caused by such ions.

More particularly, in Column 4, lines 34-37, *Warren* states that a charge in buried oxide layer 10 will cause the I-V curve to shift along the voltage axis, and that this voltage shift or

hysteresis voltage is proportional to the charge density and depends on its spatial distribution in oxide layer 10. In column 4, lines 52-55, it further notes that the observed hysteretic behavior results from an electric field induced migration of a charged ionic species from one Si/SiO_2 interface to the other, and further suggests in column 4, line 67, that the mobile charge is H^+. *Warren* proceeds to teach that rapid cooling of the device from the anneal temperature enhances the introduction of the hydrogenous ions into oxide layer 10 that is necessary to obtain the desired hysteresis voltage.

Independent Claims 1 and 7 both recite the step of heating the microcircuit in a vacuum furnace to remove any hydrogen existing in the microcircuit structure. *Warren* fails to disclose such a step. To the contrary, it teaches away by disclosing processes to introduce mobile hydrogenous ions into the semiconductor.

Claims 1 and 7 also recite the step of annealing the microcircuit with deuterium-containing forming gas. Independent Claim 12 recites substituting deuterium for hydrogen in any microcircuit fabrication step, e. g., annealing, that involves hydrogen gas or hydrogen-containing species. In column 3, lines 34-36, and also in column 5, lines 44-46, *Warren* discloses introducing H^+ or D^+ ions into the buried SiO_2 layer of the semiconductor by annealing the structure in a hydrogen or deuterium containing gas. *Warren* does not affirmatively teach the use of deuterium in annealing, or substituting deuterium for hydrogen in a fabrication step, further to radiation hardening a semiconductor by removing hydrogen; instead, it teaches that hydrogen and deuterium are alternatives to one another for the purpose of introducing hydrogenous ions into the buried SiO_2 layer. In view of the foregoing, the applicants' respectfully contend that *Warren* does not teach their limitation of annealing with deuterium, or of substituting deuterium for hydrogen in any of the other fabrication steps, with the specificity required to sustain a prima facie case of anticipation.

In conclusion, the Examiner has failed to carry his burden of establishing prima facie anticipation of Claims 1-10 and 12 because *Warren* does not disclose each of the steps recited in independent Claims 1, 7, and 12. Moreover, in disclosing processes for ensuring the availability of hydrogenous ions in a semiconductor, *Warren* teaches away from the foregoing claims. Applicants thus respectfully submit that Claims 1-10 and 12 are patentable in their present form.

Amended Claim 11 and New Claim 13

Claim 11 has been amended to include the step heating the microcircuit in a vacuum.

Claim 13 has been added. It depends from Claim 12, and further defines the invention described therein by adding the limitation that the fabricating process includes heating the microcircuit in a vacuum.

As previously noted herein, *Warren* does not disclose heating in a vacuum, and thus does not anticipate or suggest either the amended Claim 11 or new Claim 13.

Summary

In view of the foregoing remarks, the applicants submit that Claims 1-13 presently in the application are patentably distinct over the prior art and in allowable form. Accordingly, the applicants earnestly solicit their favorable consideration and respectfully request that the application be passed to issue in its present condition.

Should the Examiner find any remaining impediment to the prompt allowance of the aforementioned claims that might be resolved or overcome with the aid a telephone conference, he is cordially requested to call the undersigned at the telephone number set out below.

Respectfully submitted,

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Version of Claims with Markings to Show Changes Made

11. (amended) A radiation hardened silicon-based semiconductor microcircuit prepared by a process comprising the steps of:

fabricating the microcircuit using standard techniques of silicon-based microelectronics up to the step of heating the microcircuit [passivation using a forming gas anneal];

heating the microcircuit in a vacuum; and

annealing the microcircuit with deuterium-containing forming gas.

13. (new) The radiation hardened semiconductor microcircuit of Claim 12 wherein the process includes heating the microcircuit in a vacuum.